US009311905B2

(12) **United States Patent**
Murakami et al.

(10) **Patent No.: US 9,311,905 B2**
(45) **Date of Patent: Apr. 12, 2016**

(54) **INSTALLATION STRUCTURE FOR ACOUSTIC TRANSDUCER AND MUSICAL INSTRUMENT**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **14/813,956**

(22) Filed: **Jul. 30, 2015**

(65) **Prior Publication Data**

US 2016/0035331 A1 Feb. 4, 2016

(30) **Foreign Application Priority Data**

Aug. 1, 2014 (JP) 2014-157929

(51) **Int. Cl.**
G10H 1/32 (2006.01)
G10C 1/00 (2006.01)

(52) **U.S. Cl.**
CPC ... ***G10H 1/32*** (2013.01); ***G10C 1/00*** (2013.01)

(58) **Field of Classification Search**
CPC G10C 3/06; G10C 1/00; G10H 2230/011; G10H 1/32
See application file for complete search history.

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(57) **ABSTRACT**

An installation structure for an acoustic transducer for vibrating a vibrated body of a musical instrument in a first direction for permitting the vibrated body to generate sounds, including: the acoustic transducer having a main body and a vibrating portion that vibrates in the first direction; a support portion to be fixed to a housing of the musical instrument for supporting the main body; and a cover member fixed to the support portion for covering the acoustic transducer, wherein the support portion includes a base plate portion to be held in surface contact with the housing so as to be fixed thereto, a first fixing portion to which the main body is fixed and which supports the main body, and a second fixing portion to which the cover member is fixed, and wherein the first and second fixing portions are connected to the base plate portion independently of each other.

9 Claims, 8 Drawing Sheets

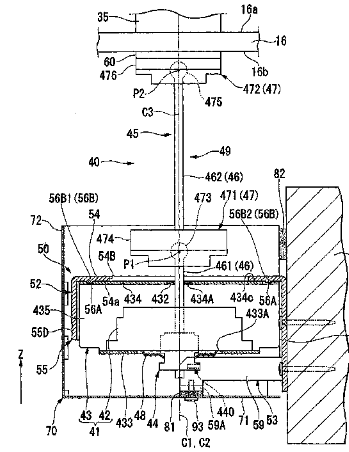

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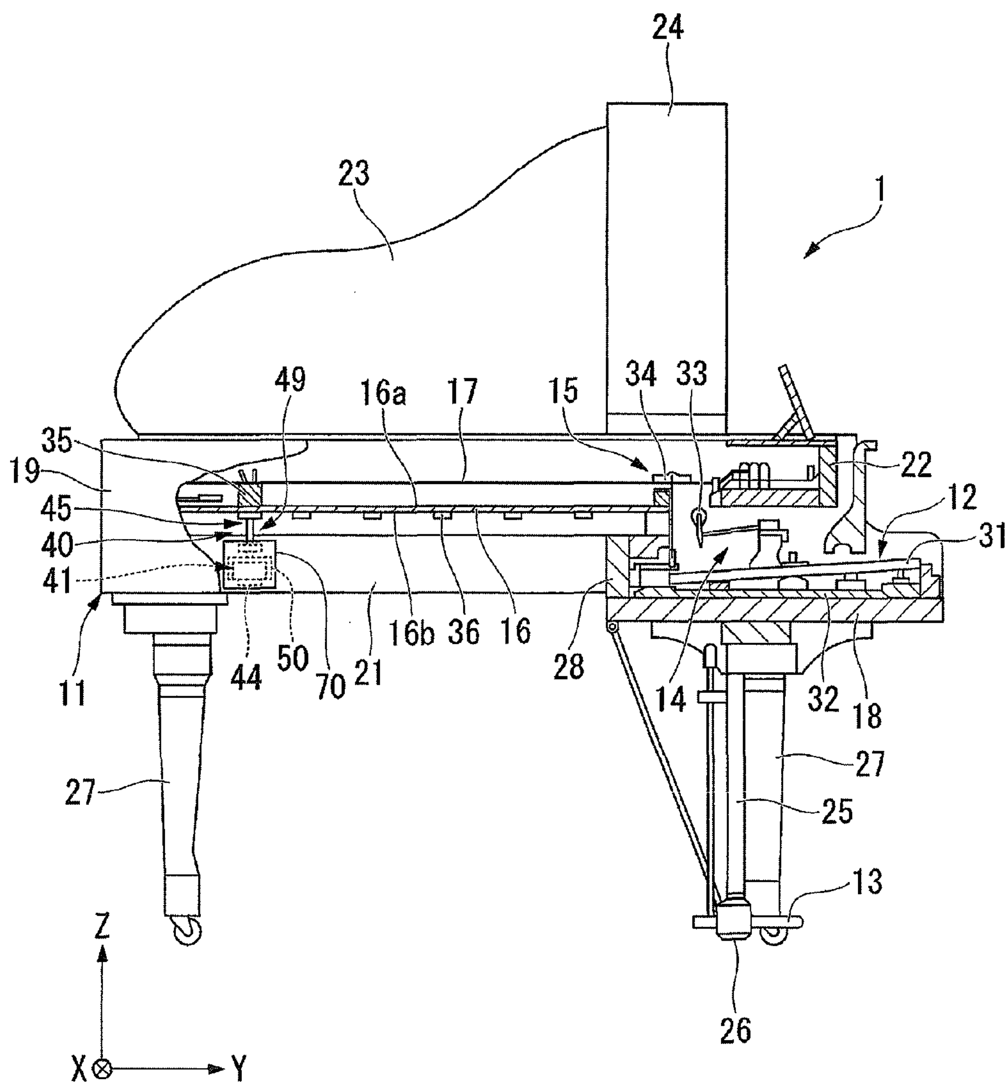
FIG.1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16b
36
16
28
14
32
18
27
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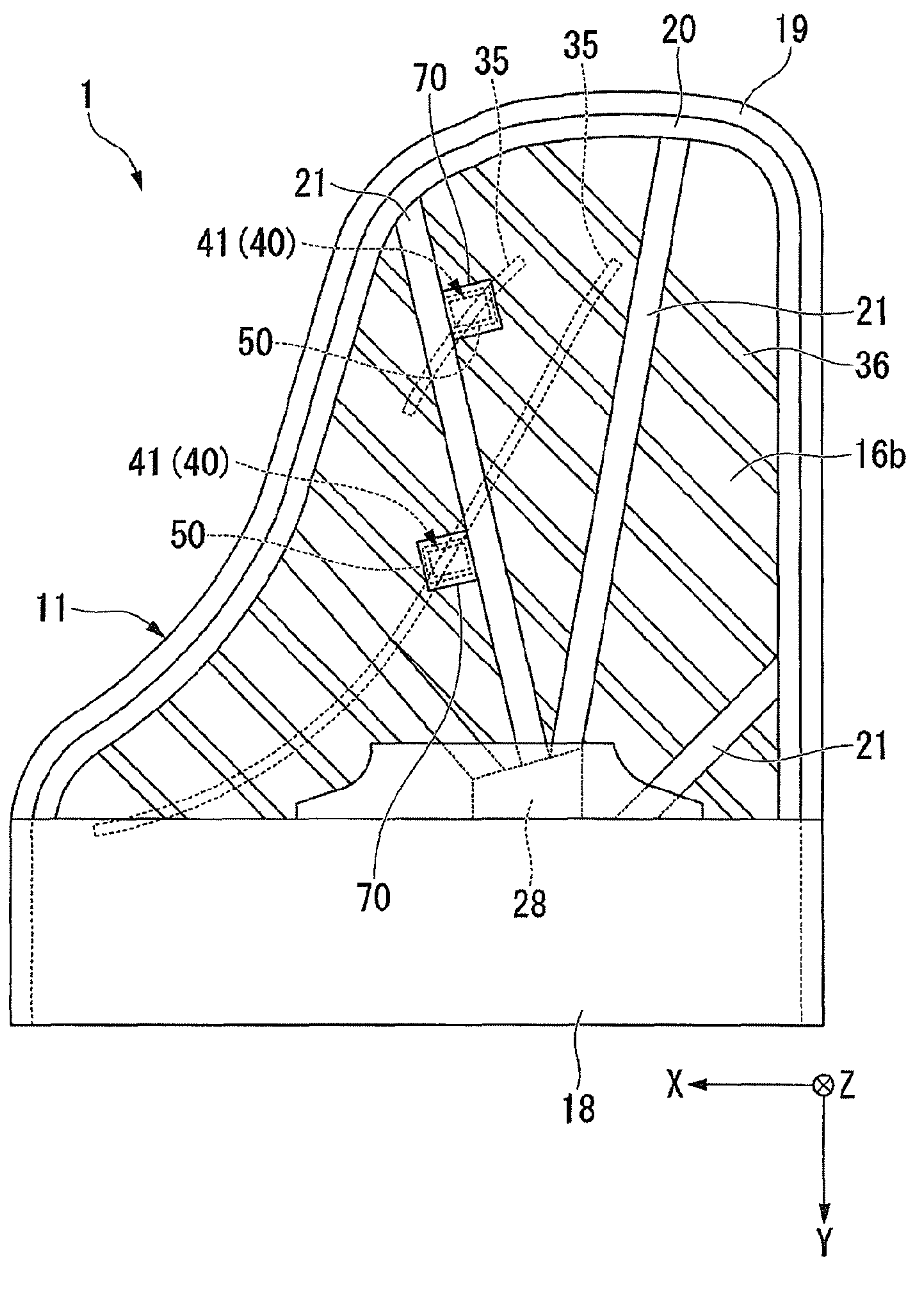
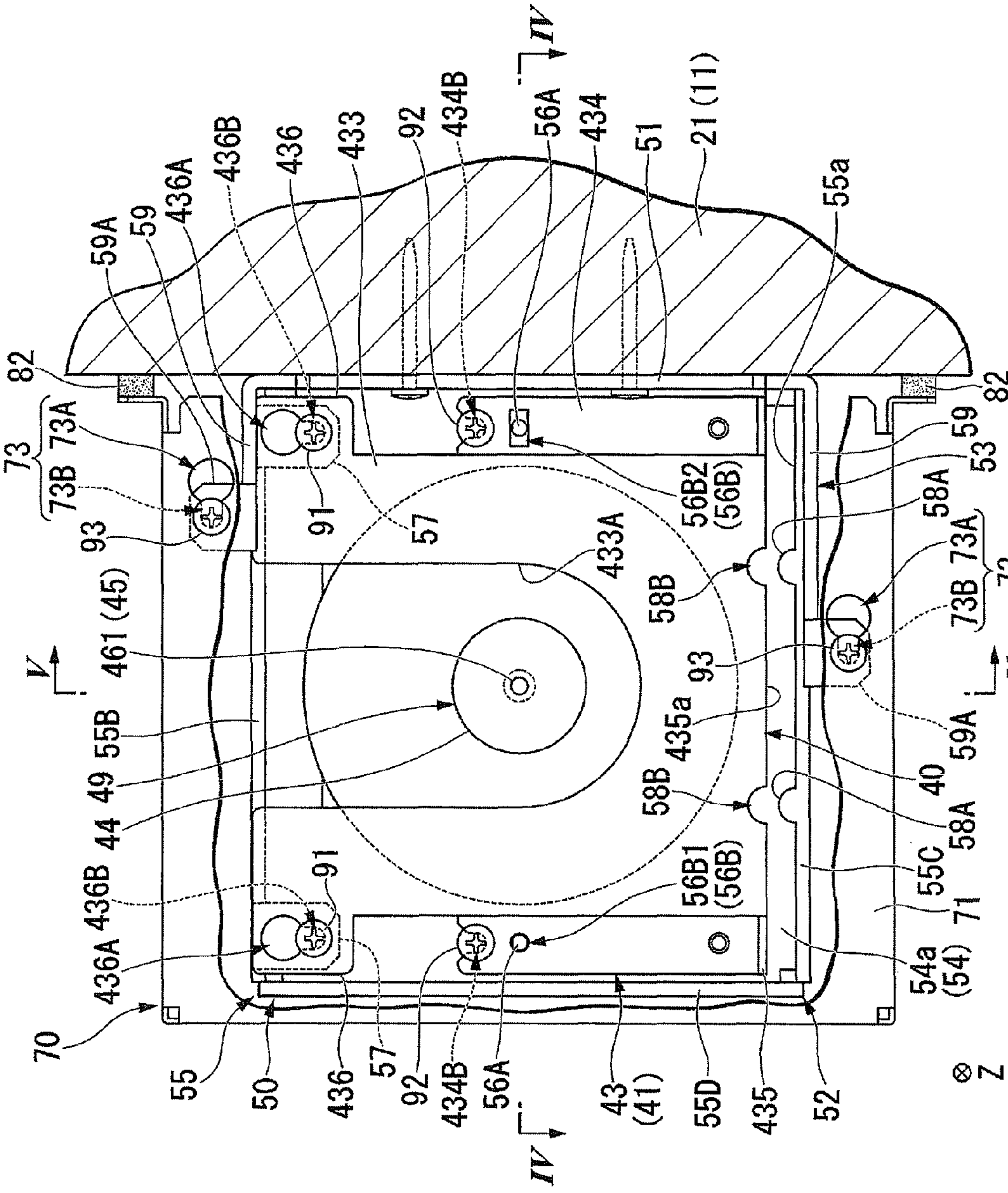
25
13
26
Z
X
Y

FIG.2

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73A
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73A
73B
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436A
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436B
436B
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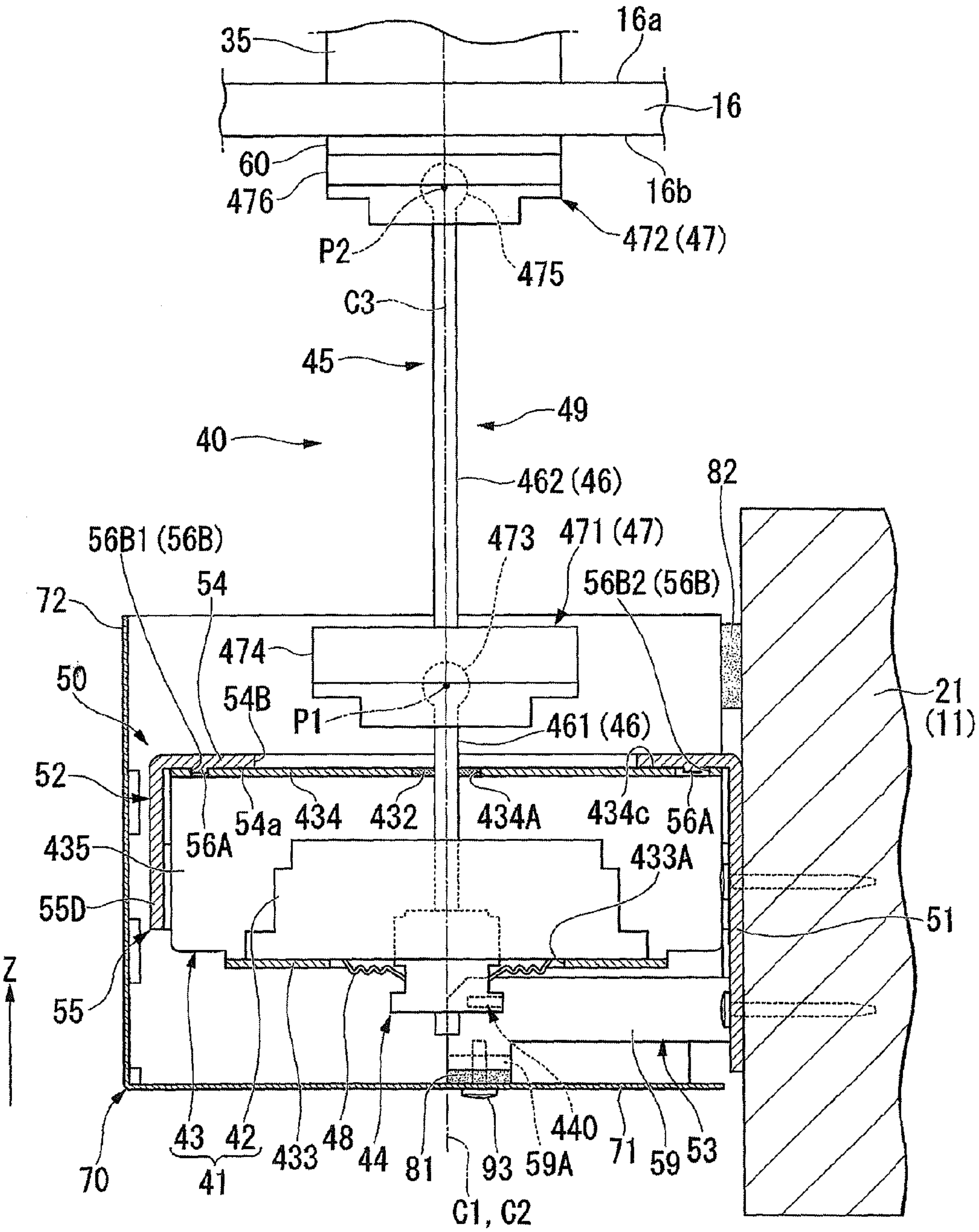
436
433
433A
92
92
434B
434B
56A
56A
434
91
91
57
57
56B2
(56B)
56B1
(56B)
461 (45)
55B
49
44
435a
40
55C
71
54a
(54)
70
55
50
43
(41)
55D
435
52
Z

FIG.3

FIG.4



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16a
16
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16b
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472 (47)
P2
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C3
45
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462 (46)
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56B2 (56B)
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(11)
P1
461 (46)
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56A
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434A
434c
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55D
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59A
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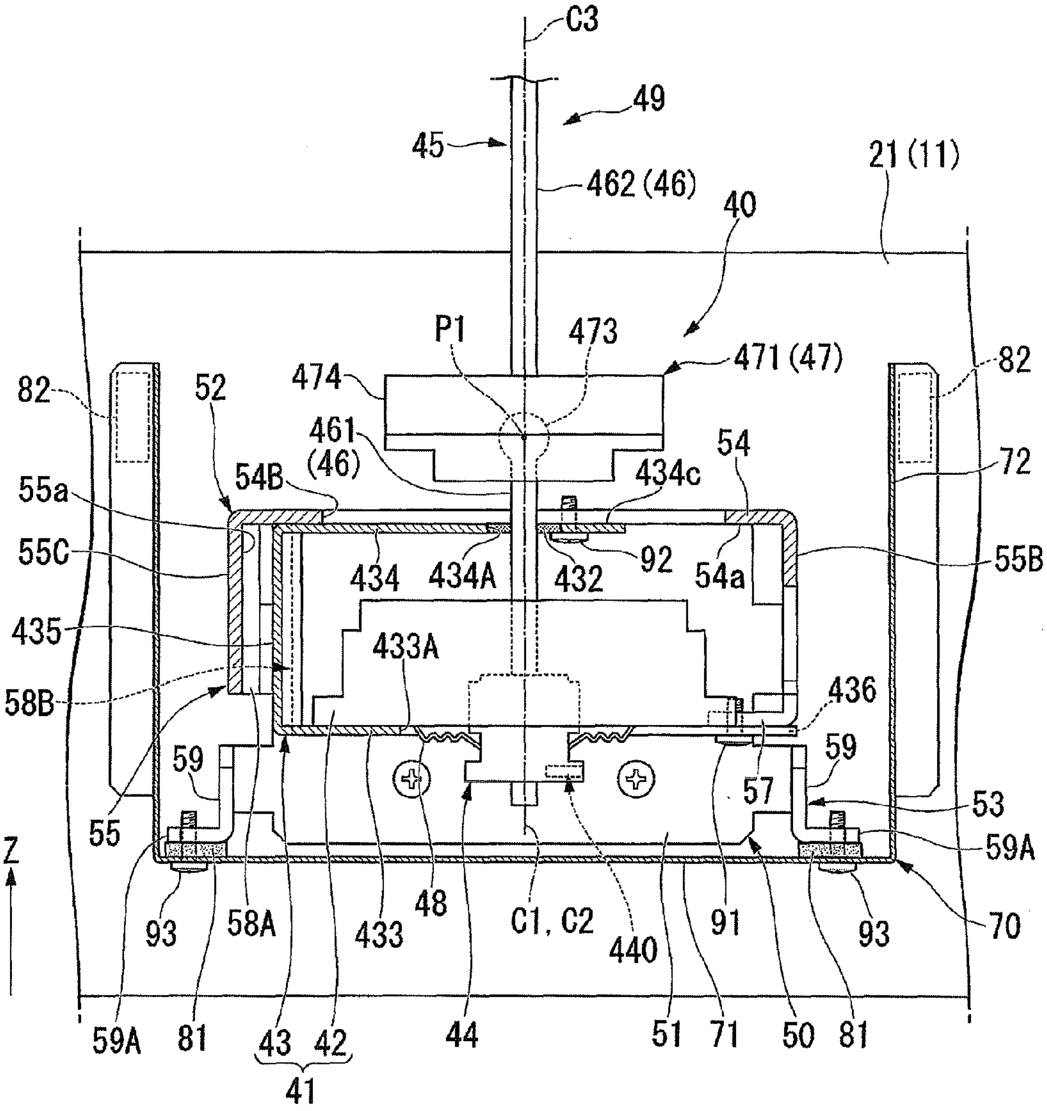
C1, C2

FIG.5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55C
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59A
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58A
48
C1, C2
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71
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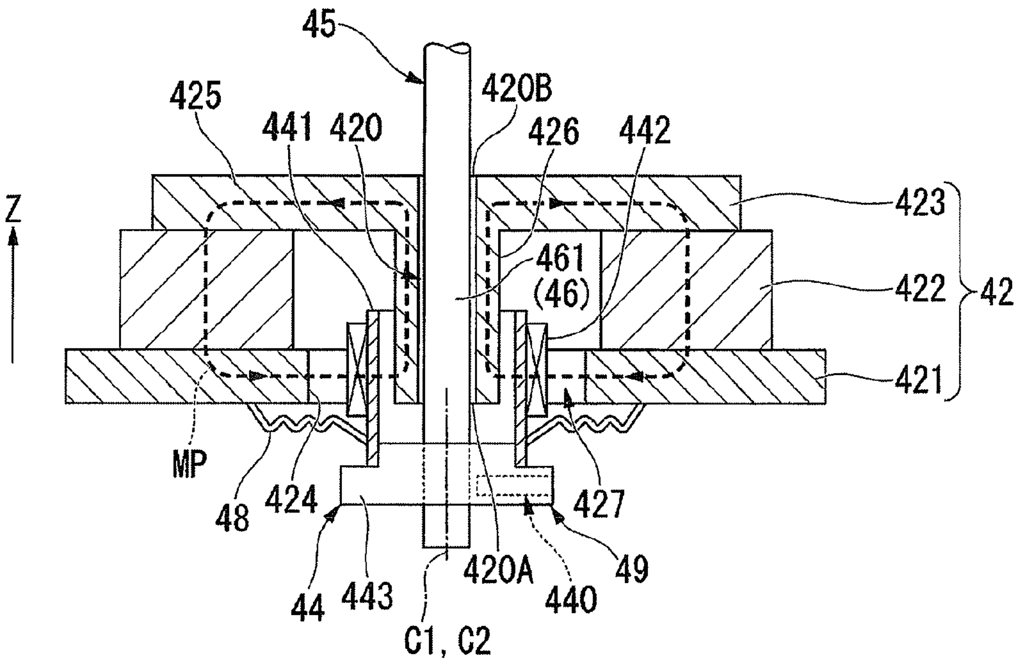
41
433
Z

FIG.6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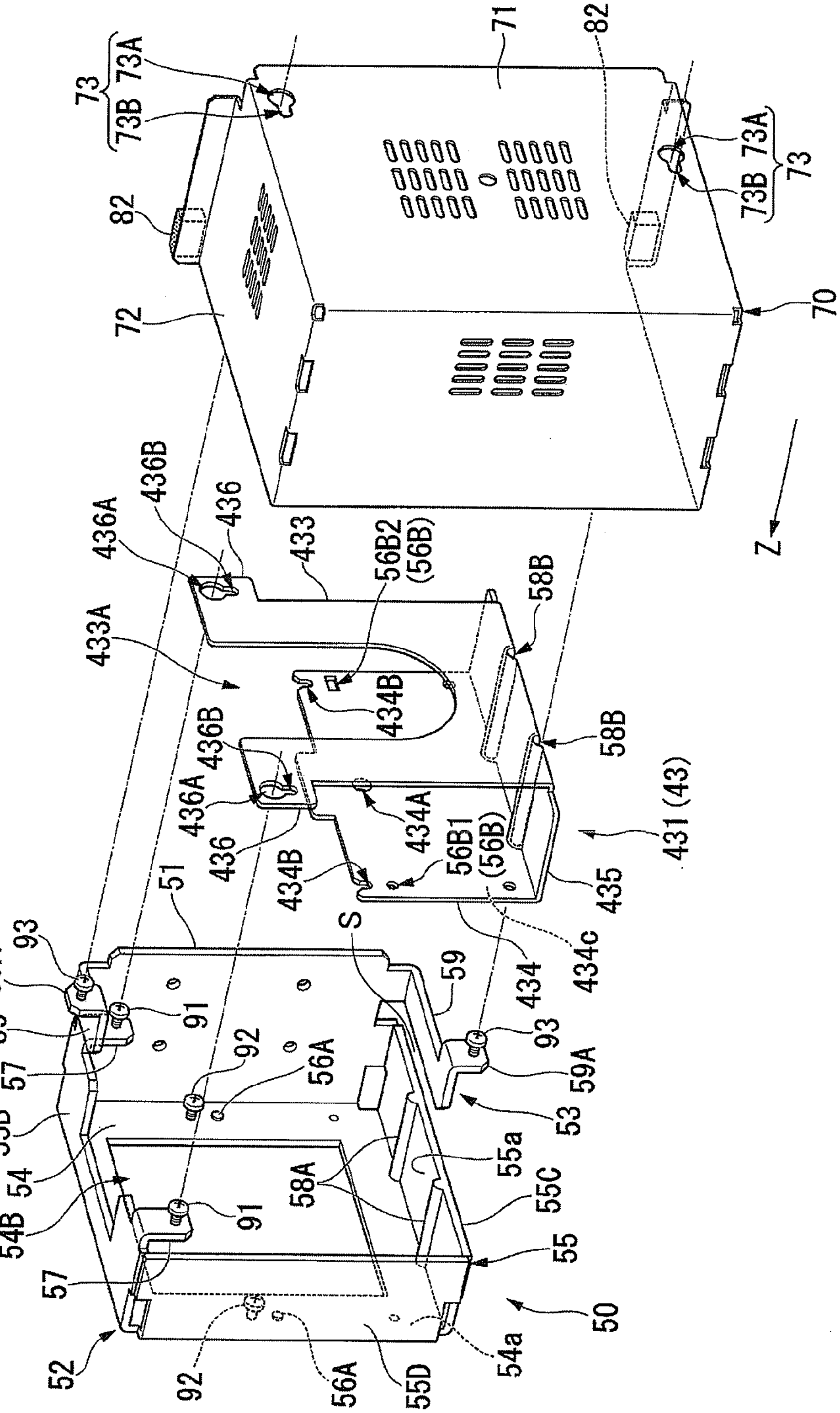
C1, C2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434c
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59A
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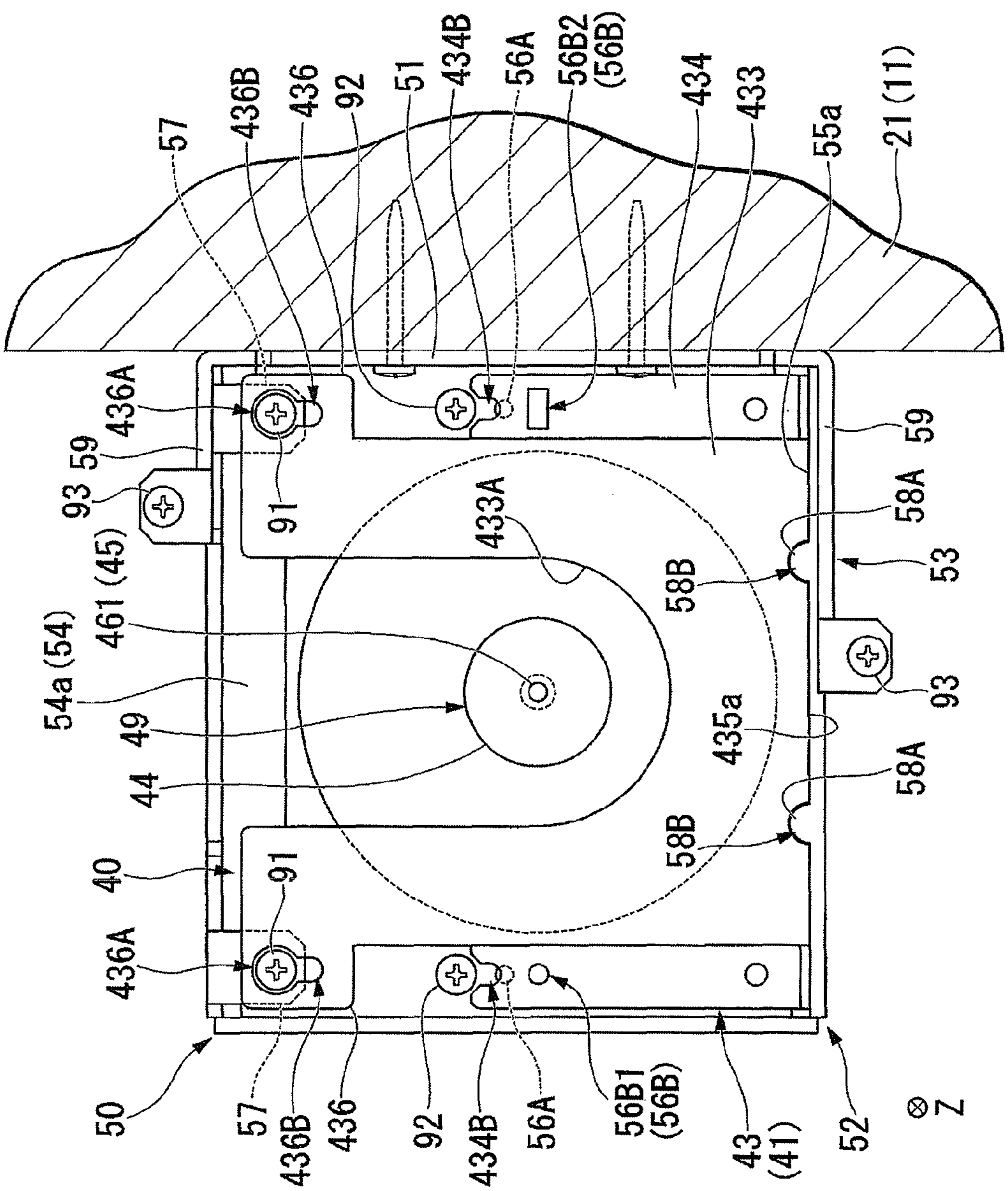
FIG. 7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58B
58A
91
436A
50
57
436B
436
92
434B
56A
56B1
(56B)
43
(41)
52
Z

FIG. 8

INSTALLATION STRUCTURE FOR ACOUSTIC TRANSDUCER AND MUSICAL INSTRUMENT

CROSS REFERENCE TO RELATED APPLICATION

The present application claims priority from Japanese Patent Application No. 2014-157929, which was filed on Aug. 1, 2014, the disclosure of which is herein incorporated by reference in its entirety.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an installation structure for an acoustic transducer and a musical instrument having the same.

2. Description of Related Art

Various conventional musical instruments such as keyboard musical instruments have an acoustic transducer installed thereon. The acoustic transducer is configured to vibrate a vibrated body such as a soundboard in a predetermined direction so as to permit the vibrated body to generate sounds. Such an acoustic transducer has a main body including a magnetic-path forming portion for forming a magnetic path and a vibrating portion configured to vibrate with respect to the main body of the acoustic transducer.

The following Patent Literature 1 discloses an installation structure for an acoustic transducer in which a main body of the acoustic transducer is fixed to a housing of a musical instrument (e.g., a back post of a grand piano) and one end of a vibrating portion of the acoustic transducer in a vibrating direction is fixed by bonding or the like to the vibrated body. When the vibrating portion is vibrated with respect to the main body (the magnetic-path forming portion), the vibrated body vibrates in a predetermined direction to thereby generate sounds.

Patent Literature 1: JP-A-2013-077000

SUMMARY OF THE INVENTION

In an instance where the thus constructed acoustic transducer is installed on a grand piano, the acoustic transducer is disposed on a lower side of the soundboard in the vertical direction. In this instance, the acoustic transducer is exposed to the exterior, and there may be a risk that the external appearance of the grand piano is impaired.

In view of the above, it may be considered to cover the acoustic transducer installed on the grand piano with a box-shaped cover member. In an instance where the cover member is fixed to the main body of the acoustic transducer, however, vibration of the vibrating portion is transmitted to the cover member via the main body of the acoustic transducer. In this instance, the cover member vibrates, whereby unintended sounds are generated from the cover member. The sounds generated based on vibration of the cover member are not preferable because such sounds are mixed, as noise, with the sounds generated based on vibration of the vibrated body.

It may be considered to fix the cover member to a housing of the grand piano such as a back post. It is, however, unfavorable to additionally provide portions at which the cover member is fixed to the housing.

The invention has been developed in view of the situations described above. It is therefore an object of the invention to provide an installation structure for an acoustic transducer in which vibration of a cover member can be prevented or reduced even when the cover member is fixed to a main body of the acoustic transducer. It is also an object of the invention to provide a musical instrument having such an installation structure for the acoustic transducer.

The object indicated above may be attained according to one aspect of the invention, which provides an installation structure for an acoustic transducer configured to vibrate a vibrated body of a musical instrument in a first direction so as to permit the vibrated body to generate sounds, comprising: the acoustic transducer having a main body and a vibrating portion configured to vibrate in the first direction with respect to the main body; a support portion to be fixed to a housing of the musical instrument so as to support the main body of the acoustic transducer; and a cover member fixed to the support portion so as to cover the acoustic transducer, wherein the support portion includes a base plate portion to be held in surface contact with the housing so as to be fixed thereto, a first fixing portion to which the main body of the acoustic transducer is fixed and which is configured to support the main body, and a second fixing portion to which the cover member is fixed, and wherein the first fixing portion and the second fixing portion are connected to the base plate portion independently of each other.

The object indicated above may be attained according to another aspect of the invention, which provides a musical instrument, comprising: the housing: the vibrated body configured to generate sounds by vibration thereof in the first direction; and the installation structure for the acoustic transducer constructed as described above.

BRIEF DESCRIPTION OF DRAWINGS

The above and other objects, features, advantages and technical and industrial significance of the present invention will be better understood by reading the following detailed description of an embodiment of the invention, when considered in connection with the accompanying drawings, in which:

FIG. **1** is a side sectional view showing a piano including an installation structure for an acoustic transducer according to one embodiment of the invention;

FIG. **2** is a view seen from an underside of the piano of FIG. **1** for explaining positions at which the acoustic transducers are installed;

FIG. **3** is an enlarged view seen from the underside of the piano of FIG. **1**, the view showing a state in which the acoustic transducer is installed on the piano;

FIG. **4** is a sectional view taken along line IV-IV in FIG. **3**;

FIG. **5** is a sectional view taken along line V-V in FIG. **3**;

FIG. **6** is a vertical sectional view of a magnetic-path forming portion and a vibrating unit shown in FIGS. **4** and **5**;

FIG. **7** is an exploded perspective view showing a restricting holder portion, a support portion, and a cover member shown in FIGS. **3**-**5**; and

FIG. **8** is a view seen from the underside of the piano for explaining a procedure of mounting the restricting holder portion shown in FIGS. **3**-**5**, and **7** onto the support portion.

DETAILED DESCRIPTION OF THE EMBODIMENT

Referring to FIGS. **1**-**8**, there will be explained one embodiment of the invention. In the present embodiment, a piano **1** which is one of keyboard musical instruments is illustrated as a musical instrument to which is applied an installation structure for an acoustic transducer according to one embodiment of the invention. In FIGS. **1** and **2**, a right-left direction and a front-rear direction as seen from a player of the piano **1** are defined as an X-axis direction and a Y-axis direction, respectively. In FIGS. **1-8**, an up-down direction as seen from the player of the piano **1** is defined as a Z-axis direction.

As shown in FIGS. **1** and **2**, the piano **1** according to the present embodiment is a grand piano which is one sort of an acoustic piano. The piano **1** has a housing **11**, a keyboard portion **12**, pedals **13**, action mechanisms **14**, damper mechanisms **15**, a soundboard (vibrated body) **16**, strings **17**, and so on.

The housing **11** includes a key bed **18**, an outer rim, an inner rim **20**, back posts **21**, a front rail **22**, a large roof **23**, a front roof **24** pivotally connected to a front end of the large roof **23**, pedal posts **25**, a pedal box **26**, and leg posts **27**.

The keyboard portion **12** which will be explained is placed on the key bed **18**.

The outer rim **19** is fixed to the side edges of the key bed **18** so as to extend rearward of the key bed **18**, namely, so as to extend leftward in FIG. **1**.

The inner rim **20** is fixed along the inner surface of the outer rim **19**. The back posts **21** extend generally in the front-rear direction between the inner rim **20** and a collector **28** fixed to the rear end of the key bed **18**. Each back post **21** is disposed at a position near the lower end portion of the outer rim **19**. The inner rim **20** and the back posts **21** have a function of permitting the outer rim **19** to have rigidity.

The front rail **22** is disposed above the key bed **18** (i.e., the upper side in FIG. **1**) on the front-end side of the outer rim **19** (i.e., the right side in FIG. **1**) so as to define a front surface of the housing **11**. A part of the key bed **18** protrudes forward of the front rail **22**.

The large roof **23** is pivotally connected to the outer rim **19** on the rear side of the front rail **22**. The large roof **23** is configured to pivot relative to the outer rim **19**, together with the front roof **24**, so as to be selectively positioned at one of: a closed position at which the large roof **23** and the front roof **24** are held in contact with the upper end of the outer rim **19** so as to cover an opening above the outer rim **19**; and an open position at which the opening is not covered, namely, the opening is exposed to the exterior. In FIG. **1**, the large roof **23** and the front roof **24** are placed at the open position.

The pedal posts **25** extend downward on the lower side of the key bed **18**. The pedal box **26** is fixed to the distal ends of the pedal posts **25**.

The leg posts **27** extend downward from portions of the lower surface of the key bed **18** on the front-surface side of the housing **11**, which portions are located on opposite sides of the pedal posts **25** in the right-left direction, and from the lower portions of the inner rim **20** and the back post **21** on the rear-end side of the housing **11**.

The keyboard portion **12** has a plurality of keys **31** which are arranged in the right-left direction and which are operated by fingers of a player for performance. Each key **31** is pivotally disposed on the key bed **18** via a key frame **32**. The front end portion of each key **31** is exposed to the exterior on the front-surface side of the housing **11** (i.e., the right side in FIG. **1**).

The pedals **13** are operating members each of which is operated by a foot of the player and are provided so as to protrude from the front surface of the pedal box **26**.

The action mechanism **14** and the damper mechanism **15** are provided for each key **31** and are disposed above the rear end portion of the corresponding key **31**. The action mechanism **14** is a mechanism for converting a force by which the key **31** is depressed by a finger of the player (key depression force) into a force by which the string **17** is struck by a hammer **33** (string striking force or the hitting force).

The damper mechanism **15** is a mechanism for converting the key depression force and a force by which a damper pedal (which is one of the pedals **13**) is stepped on by a foot of the player (stepping force), into a force by which dampers **34** on the strings **17** are released therefrom (string release force).

The soundboard **16** is disposed on the inner side of the outer rim **19** between the large roof **23** positioned at the closed position and the back posts **21**, such that the thickness direction of the soundboard **16** coincides with the up-down direction.

The strings **17** are provided so as to correspond to the keys **31** and are stretched over an upper surface **16*a*** of the soundboard **16**.

There are provided, on the upper surface **16*a*** of the soundboard **16**, bridges **35** partially engaging with the strings **17**. There are provided soundboard ribs **36** on a lower surface **16*b*** of the soundboard **16** opposed to the back posts **21**.

In the thus constructed piano **1**, when one string **17** is struck by the hammer **33** and is accordingly vibrated, the vibration of the one string **17** is transmitted to the soundboard **16** via the bridge **35** and the soundboard **16** is accordingly vibrated. The vibration of the soundboard **16** propagates through the air, so that sounds are generated. That is, the soundboard **16** generates sounds by being vibrated. The vibration of the soundboard **16** is also transmitted to other strings **17** via the bridges **35**, so that other strings **17** are vibrated.

The soundboard **16** is vibrated in the thickness direction thereof, namely, in the Z-axis direction. In the following explanation, the direction of the vibration of the soundboard **16** will be referred to as a “predetermined direction” (as one example of a first direction).

The piano **1** of the present embodiment has acoustic transducers **40** configured to vibrate the soundboard **16** in the predetermined direction (the Z-axis direction) so as to cause the soundboard **16** to generate sounds. Hereinafter, the acoustic transducers **40** will be explained referring to FIGS. **3-7**.

As shown in FIGS. **3** and **4**, the acoustic transducer **40** is an actuator of a voice coil type and includes a main body **41** and a vibrating portion **49**.

The main body **41** includes a magnetic-path forming portion **42** for forming a magnetic path. As shown in FIG. **6**, an insertion hole **420** is formed through the magnetic-path forming portion **42** in the predetermined direction (the Z-axis direction) for permitting a connecting unit **45** (which will be explained) to pass through the insertion hole **420**.

The magnetic-path forming portion **42** of the present embodiment includes a top plate **421**, a magnet **422**, and a yoke **423**.

The top plate **421** is formed of a soft magnetic material such as soft iron. The top plate **421** is shaped like a disc and has a through-hole **424** at its center.

The yoke **423** is formed of a soft magnetic material such as soft iron and is integrally constituted by a disc portion **425** and a cylindrical portion **426** that protrudes from the center of the disc portion **425**. The axis of the disc portion **425** and the axis of the cylindrical portion **426** coincide with each other. The cylindrical portion **426** has an outer diameter smaller than an inner diameter of the through-hole **424** of the top plate **421**. The above-indicated insertion hole **420** of the magnetic-path forming portion **42** is formed through the disc portion **425** and the cylindrical portion **426** of the yoke **423** in the axis direction thereof.

The magnet **422** is a permanent magnet having an annular shape. The magnet **422** has an inner diameter larger than the inner diameter of the through-hole **424** of the top plate **421**.

The magnet **422** is fixed to the disc portion **425** of the yoke **423** in a state in which the cylindrical portion **426** of the yoke **423** passes through the magnet **422**. The top plate **421** is fixed to the magnet **422** such that the magnet **422** is sandwiched between the top plate **421** and the disc portion **425** of the yoke **423** and such that the distal end portion of the cylindrical portion **426** is disposed in the through-hole **424** of the top plate **421**.

In a state in which the top plate **421**, the magnet **422**, and the yoke **423** are fixed with one another, the axes thereof coincide with one another and define an axis C**1** of the magnetic-path forming portion **42**.

In the thus constructed magnetic-path forming portion **42** of the present embodiment, there is formed a magnetic path MP that passes the top plate **421**, the cylindrical portion **426**, and the disc portion **425** in order from the magnet **422** and returns to the magnet **422**. In this arrangement, there is generated, between the inner circumferential surface of the through-hole **424** of the top plate **421** and the outer circumferential surface of the cylindrical portion **426** of the yoke **423**, a magnetic field including a component in the diametrical direction of the cylindrical portion **426**. That is, a space between the inner circumferential surface of the through-hole **424** of the top plate **421** and the outer circumferential surface of the cylindrical portion **426** of the yoke **423** functions as a magnetic space **427** in which the magnetic field indicated above is generated.

The vibrating portion **49** is connected to the soundboard **16** and vibrates in the predetermined direction (the Z-axis direction) with respect to the magnetic-path forming portion **42**. The vibrating portion **49** includes a vibrating unit **44** and the connecting unit **45**.

The vibrating unit **44** is configured to vibrate in the predetermined direction (the Z-axis direction) with respect to the magnetic-path forming portion **42**. The vibrating unit **44** is disposed on one side of the insertion hole **420** of the magnetic-path forming portion **42** nearer to an opening **420**A. The vibrating unit **44** is supported by the magnetic-path forming portion **42** through a damper portion **48**. The vibrating unit **44** is removably fixed to the connecting unit **45** by fixing means **440**. The vibrating unit **44** of the present embodiment will be explained detail below.

The vibrating unit **44** includes a bobbin **441**, a voice coil **442**, and a cap **443**.

The bobbin **441** has a cylindrical shape. The bobbin **441** in which the cylindrical portion **426** of the magnetic-path forming portion **42** is inserted is inserted in the through-hole **424** of the top plate **421**. The axis of the bobbin **441** defines an axis C**2** of the vibrating unit **44**.

The voice coil **442** is constituted by conductive wires wound around the outer circumferential surface of the bobbin **441** at one end portion of the bobbin **441** in a direction of extension of the axis C**2** (hereinafter simply referred to as “axis C**2** direction” where appropriate.

The cap **443** is fixed to the bobbin **441** so as to close an opening of the bobbin **441** at the other end portion thereof in the axial direction. The cap **443** is provided with a hole which is formed through the thickness thereof in the axial direction of the bobbin **44** land into which the connecting unit **45** is insertable. The cap **443** is further provided with the above-indicated fixing means **440** for the vibrating unit **44**. The fixing means **440** is configured to fix, to the cap **443**, the connecting unit **45** inserted in the hole of the cap **443**. The fixing means **440** is a chuck device, for instance.

The vibrating unit **44** is attached to the magnetic-path forming portion **42** by the damper portion **48** such that the one end portion of the bobbin **441** around which the voice coil **442** is wound is located in the magnetic space **427** of the magnetic-path forming portion **42** that is formed on the one side of the insertion hole **420** nearer to the opening **420**A and such that the other end portion of the bobbin **441** protrudes from the magnetic-path forming portion **42**.

The damper portion **48** has a function of supporting the vibrating unit **44** such that the vibrating unit **44** does not contact the magnetic-path forming portion **42**. The damper portion **48** further has a function of permitting the axis C**2** of the vibrating unit **44** to coincide with the axis C**1** of the magnetic-path forming portion **42** and supporting the vibrating unit **44** such that the vibrating unit **44** is displaceable in a direction of extension of the axis C**1** of the magnetic-path forming portion **42** with respect to the magnetic-path forming portion **42**. (The direction of extension of the axis C**1** will be hereinafter simply referred to as “axis C**1** direction” where appropriate.)

The damper portion **48** of the present embodiment has an annular shape. The damper portion **48** has a bellows-like shape waved in its diametrical direction. The damper portion **48** is fixed at its inner periphery to the other end portion of the bobbin **441** and at its outer periphery to the top plate **421**. The damper portion **48** is formed of a fiber, a resin material, or the like, so as to be elastically deformable.

In the acoustic transducer **40** having the magnetic-path forming portion **42** and the vibrating unit **44** constructed as described above, when an electric current in accordance with an audio signal passes through the voice coil **442** disposed in the magnetic space **427**, the vibrating unit **44** vibrates in the axis C**1** direction of the magnetic-path forming portion **42**. The audio signal is generated in a controller (not shown) as a drive signal for driving the vibrating unit **44**, on the basis of audio data stored in a memory (not shown), for instance.

As shown in FIG. **4**, the connecting unit **45** connects the vibrating unit **44** and the soundboard **16** to each other so as to transmit vibration of the vibrating unit **44** to the soundboard **16**.

The connecting unit **45** of the present embodiment includes: a shaft portion **46** extending between the vibrating unit **44** and the soundboard **16**; and a joint portion **47** configured to allow at least a part of the shaft portion **46** to incline with respect to the predetermined direction (the Z-axis direction).

The shaft portion **46** of the present embodiment includes: a rod-like vibrating-side shaft portion **461** that protrudes, toward the soundboard **16**, from one side of the acoustic transducer **40** on which the vibrating unit **44** is located; and a rod-like vibrated-side shaft portion **462** that protrudes, toward the vibrating unit **44**, from another side of the acoustic transducer **40** on which the soundboard **16** is located. The joint portion **47** of the present embodiment includes: an intermediate joint portion **471** that connects the vibrating-side shaft portion **461** and the vibrated-side shaft portion **462** to each other; and a distal joint portion **472** provided at one axial end of the vibrated-side shaft portion **462** nearer to the soundboard **16**.

As shown in FIGS. **4-6**, a first axial end of the vibrating-side shaft portion **461** is removably fixed to the vibrating unit **44** by the fixing means **440**. In the present embodiment, the first axial end of the vibrating-side shaft portion **461** is fixed to the cap **443** of the vibrating unit **44** by the fixing means **440** with the first axial end inserted in the insertion hole **420** of the magnetic-path forming portion **42**. Thus, the axis of the vibrating-side shaft portion **461** coincides with the axis C**2** of the vibrating unit **44**. In this state, a second axial end of the vibrating-side shaft portion **461** protrudes from another opening **420**B of the insertion hole **420** toward the soundboard **16**.

As shown in FIGS. **4** and **5**, a first axial end of the vibrated-side shaft portion **462** is connected to the vibrating-side shaft portion **461** via the intermediate joint portion **471**. A second axial end of the vibrated-side shaft portion **462** is connected to the soundboard **16** via the distal joint portion **472**.

The intermediate joint portion **471** allows the axis C**2** of the vibrating-side shaft portion **461** and the axis C**3** of the vibrated-side shaft portion **462** to incline relative to each other. The intermediate joint portion **471** of the present embodiment has the so-called ball joint structure.

The intermediate joint portion **471** includes a spherical portion **473** and a retainer portion **474** that rotatably holds the spherical portion **473**. In the present embodiment, the spherical portion **473** is formed at the second axial end of the vibrating-side shaft portion **461** while the retainer portion **474** is provided at the first axial end of the vibrated-side shaft portion **462**. The spherical portion **473** may be formed at the first axial end of the vibrated-side shaft portion **462** while the retainer portion **474** may be provided at the second axial end of the vibrating-side shaft portion **461**. In the present embodiment, a center P**1** of the spherical portion **473** is located on the axis C**2** of the vibrating-side shaft portion **461**.

The center P**1** of the intermediate joint portion **471** constructed as described above is located on both of the axis C**2** of the vibrating-side shaft portion **461** and the axis C**3** of the vibrated-side shaft portion **462**. Thus, the axis C**2** of the vibrating-side shaft portion **461** and the axis C**3** of the vibrated-side shaft portion **462** can incline relative to each other about the center P**1** of the intermediate joint portion **471**. That is, the connecting unit **45** of the present embodiment is bendable at the intermediate joint portion **471**.

As shown in FIG. **4**, the distal joint portion **472** allows the axis C**3** of the vibrated-side shaft portion **462** to incline relative to the predetermined direction (the Z-axis direction). The distal joint portion **472** has a ball joint structure similar to that of the intermediate joint portion **471**.

The distal joint portion **472** includes a spherical portion **475** and a retainer portion **476** similar to those of the intermediate joint portion **471**. In the distal joint portion **472** of the present embodiment, the spherical portion **475** is formed at the second axial end of the vibrated-side shaft portion **462** while the retainer portion **476** is fixed to the soundboard **16** via an intervening member **60** (which will be explained). A center P**2** of the spherical portion **475** is located on the axis C**3** of the vibrated-side shaft portion **462**.

That is, the center P**2** of the distal joint portion **472** is located on the axis C**3** of the vibrated-side shaft portion **462**. Thus, the axis C**3** of the vibrated-side shaft portion **462** can incline relative to the predetermined direction (the Z-axis direction) about the center P**2** of the distal joint portion **472**.

As shown in FIGS. **3**-**5** and **7**, the main body **41** of the acoustic transducer **40** of the present embodiment has a restricting holder portion **43** engaging with the vibrating-side shaft portion **461** and configured to restrict a movement of the vibrating-side shaft portion **461** in a direction intersecting the axis C**2** direction while allowing a movement of the vibrating-side shaft portion **461** in the axis C**2** direction, at a position at which the restricting holder portion **43** engages with the vibrating-side shaft portion **461**.

The restricting holder portion **43** includes a frame portion **431** and a contact member **432**.

The frame portion **431** is formed by bending a plate member formed of metal or the like. The frame portion **431** includes: a fixing plate portion **433** which is shaped like a flat plate and to which the magnetic-path forming portion **42** is fixed such that the axis C**1** direction of the magnetic-path forming portion **42** coincides with the thickness direction of the fixing plate portion **433**; an engaging plate portion **434** disposed in parallel with the fixing plate portion **433** such that the magnetic-path forming portion **42** is disposed between the engaging plate portion **434** and the fixing plate portion **433**; and a connecting plate portion **435** which extends, on the side portion of the magnetic-path forming portion **42**, in the direction of the axis C**1** of the magnetic-path forming portion **42** and which connects the fixing plate portion **433** and the engaging plate portion **434** to each other.

Onto the fixing plate portion **433**, one end surface of the magnetic-path forming portion **42** from which the vibrating unit **44** protrudes is superposed and fixed. The fixing plate portion **433** is provided with an opening hole **433**A formed through the thickness thereof for preventing the fixing plate portion **433** from interfering with the vibrating unit **44** and the vibrating-side shaft portion **461** that protrude from the magnetic-path forming portion **42**. In the present embodiment, the opening hole **433**A shown in FIG. **7** is open to the distal end of the fixing plate portion **433** in a direction in which the fixing plate portion **433** extends from the connecting plate portion **435**. The opening hole **433**A may be open otherwise.

A part of the fixing plate portion **433** is formed as screw-fastening plate portions **436** for fastening the frame portion **431** to a support portion **50** (that will be explained) by first fixing screws **91**. Each screw-fastening plate portion **436** is provided with a head insertion hole **436**A and a shaft insertion hole **436**B which are formed through the thickness of the screw-fastening plate portion **436**.

The head insertion hole **436**A has an inner diameter larger than a diameter of the head of the first fixing screw **91**. The shaft insertion hole **436**B has an inner diameter smaller than the diameter of the head of the first fixing screw **91** and larger than a diameter of the shaft of the first fixing screw **91**.

The head insertion hole **436**A and the shaft insertion hole **436**B are formed so as to be continuous to each other in a direction along the major (main) surface of the fixing plate portion **433** (the screw-fastening plate portions **436**). In the present embodiment, the head insertion hole **436**A is located nearer to the distal end of the fixing plate portion **433** in the extension direction thereof than the shaft insertion holes **436**B.

The screw-fastening plate portions **436** extend sideways (i.e., the right-left direction in FIG. **3**) from opposite side portions of the fixing plate portion **433** at the distal end of the fixing plate portion **433** in the extension direction thereof. That is, one head insertion hole **436**A and one shaft insertion hole **436**B are provided on each side portions of the fixing plate portion **433**. A width dimension of the fixing plate portion **433** including the screw-fastening plate portions **436** (i.e., a dimension of the fixing plate portion **433** in the right-left direction in FIG. **3**) is set to be equal to a width dimension of the engaging plate portion **434** and the connecting plate portion **435**. That is, a width dimension of the fixing plate portion **433** without including the screw-fastening plate portions **436** is set to be smaller than the width dimension of the engaging plate portion **434** and the connecting plate portion **435**.

The engaging plate portion **434** is disposed between the magnetic-path forming portion **42** fixed to the fixing plate portion **433** and the intermediate joint portion **471** of the connecting unit **45**. The engaging plate portion **434** is provided with a hole **434**A formed through the thickness thereof for permitting the vibrating-side shaft portion **461** of the connecting unit **45** to pass through the hole **434**A. The length of extension of the engaging plate portion **434** from the connecting plate portion **435** is made as small as possible while enabling formation of the hole **434**A. That is, the length of extension of the engaging plate portion **434** is set to be smaller than the length of extension of the fixing plate portion **433** from the connecting plate portion **435**.

In the present embodiment, the engaging plate portion **434** partly functions as screw-fastening plate portions for fastening the frame portion **431** to the support portion **50** by second fixing screws **92**. A shaft insertion hole **434**B is formed through each of portions of the engaging plate portion **434** functioning as the screw-fastening plate portion, for permitting the shaft of the second fixing screw **92** to pass therethrough. The shaft insertion hole **434**B has an inner diameter smaller than a diameter of the head of the second fixing screw **92** and larger than a diameter of the shaft of the second fixing screw **92**.

The shaft insertion holes **434**B are open to the edge of the major (main) surface of the engaging plate portion **434**. The direction in which the shaft insertion holes **434**B are open coincides with a direction in which the shaft insertion holes **436**B formed in the fixing plate portion **433** are open with respect to the head insertion holes **436**A. In the present embodiment, the shaft insertion holes **434**B are open to the distal end of the engaging plate portion **434** in the extension direction thereof from the connecting plate portion **435**. The shaft insertion holes **434**B are formed at respective side portions of the engaging plate portion **434** that do not overlap the fixing plate portion **433**. That is, the shaft insertion holes **434**B are provided at widthwise opposite end portions of the engaging plate portion **434** (i.e., the opposite end portions of the engaging plate portion **434** in the right-left direction in FIG. **3**).

As shown in FIGS. **4** and **5**, the contact member **432** of the restricting holder portion **43** has an annular shape and is formed of a soft fiber member such as felt or cloth. The contact member **432** is fixed by bonding or the like to the inner circumferential surface of the hole **434**A of the engaging plate portion **434**. The contact member **432** functions as a bushing for filling a clearance between the hole **434**A of the engaging plate portion **434** and the vibrating-side shaft portion **461** passing through the hole **434**A. That is, the contact member **432** is held in contact with a part of the vibrating-side shaft portion **461** located within the hole **434**A of the engaging plate portion **434** and is held in engagement with the vibrating-side shaft portion **461**.

The thus configured restricting holder portion **43** restricts a movement of the vibrating-side shaft portion **461** in a direction orthogonal to the axis C**2** direction while allowing a movement of the vibrating-side shaft portion **461** in the axis C**2** direction, at the position at which the contact member **432** engages with the vibrating-side shaft portion **461**.

Referring next to FIGS. **1-5** and **7**, the installation structure for installing the acoustic transducer **40** constructed as described above on the piano **1** will be explained.

As shown in FIGS. **1-4**, the main body **41** of the acoustic transducer **40** is fixed to the housing **11**. The main body **41** is fixed to the housing **11** such that the main body **41** is opposed to the lower surface **16***b* of the soundboard **16** with a spacing left therebetween and such that the axis C**2** of the magnetic-path forming portion **42** is parallel to the predetermined direction (the Z-axis direction) orthogonal to the lower surface **16***b* of the soundboard **16**.

In the present embodiment, the main body **41** is fixed to the housing **11** via the support portion **50**. The support portion **50** is fixed to a side surface of the back post **21** of the housing **11** (i.e., a surface of the back post **21** extending in the Z-axis direction) so as to be disposed between the soundboard **16** and the main body **41**, for supporting the main body **41**.

As shown in FIGS. **3-5** and **7**, the support portion **50** of the present embodiment is formed by bending a plate member formed of metal or the like. The support portion **50** includes a flat base plate portion **51** and a first fixing portion **52**.

The base plate portion **51** is fixed to the back post **21** by screwing or the like in a state in which the base plate portion **51** is superposed on the side surface of the back post **21** so as to be held in surface contact therewith.

The main body **41** of the acoustic transducer **40** is fixed to and supported by the first fixing portion **52**. The first fixing portion **52** extends, with respect to the base plate portion **51**, in a direction away from the side surface of the back post **21** (as one example of a second direction intersecting the Z-axis direction).

The first fixing portion **52** includes: a flat positioning plate portion **54** disposed between the soundboard **16** and the main body **41**; and a surrounding plate portion **55** that extends from the periphery of the positioning plate portion **54** in the vertically downward direction (i.e., toward a negative side in the Z-axis direction) so as to cooperate with the base plate portion **51** to surround the main body **41**.

The positioning plate portion **54** is disposed so as to be parallel with the soundboard **16**. A surface of the positioning plate portion **54** facing vertically downward is a contact surface **54***a* with which the main body **41** of the acoustic transducer is held in surface contact. The engaging plate portion **434** of the frame portion **431** of the main body **41** is held in surface contact with the contact surface **54***a* of the positioning plate portion **54**. It is thus possible to position the main body **41** with respect to the housing **11** and the soundboard **16** in the predetermined direction (the Z-axis direction).

The positioning plate portion **54** is provided with an opening hole **54**B formed through the thickness thereof for permitting the connecting unit **45** of the acoustic transducer **40** to pass through the opening hole **54**B.

The second fixing screws **92** are screwed in the positioning plate portion **54** in a direction toward the contact surface **54***a* from the negative (lower) side in the Z-axis direction. The second fixing screws **92** are for screwing the engaging plate portion **434** to the positioning plate portion **54** in a state in which the engaging plate portion **434** is held in surface contact with the contact surface **54***a*. The two second fixing screws **92** are disposed in a direction of extension of the first fixing portion **52** with respect to the base plate portion **51** (i.e., the right-left direction in FIG. **3**). A spacing distance between the two second fixing screws **92** is the same as a spacing distance between the two shaft insertion holes **434**B formed in the engaging plate portion **434**.

In the structure described above, the shafts of the respective second fixing screws **92** are inserted into the respective shaft insertion holes **434**B of the engaging plate portion **434**, whereby the engaging plate portion **434** can be fastened to the positioning plate portion **54** by the second fixing screws **92**. The shaft insertion holes **434**B of the engaging plate portion **434** are open to the distal end of the engaging plate portion **434** in the extension direction thereof. It is thus possible to insert the shafts of the second fixing screws **92**, which are screwed in advance in the positioning plate portion **54**, into the respective shaft insertion holes **434**B of the engaging plate portion **434** by moving the engaging plate portion **434** in a direction along the contact surface **54***a* in a state in which the engaging plate portion **434** is held in contact with the contact surface **54***a*.

The positioning plate portion **54** is provided with positioning engaging portions configured to engage with the main body **41** of the acoustic transducer **40** in a state in which the main body **41** is held in surface contact with the contact surface **54***a*, so as to prevent the main body **41** from moving along the contact surface **54***a*. That is, the positioning engaging portions have a function of positioning the main body **41** with respect to the housing **11** and the soundboard **16** in an orthogonal direction that is orthogonal to the predetermined direction (the Z-axis direction).

In the present embodiment, the positioning engaging portions are positioning protrusions **56**A that protrude from the positioning plate portion **54**. A plurality of positioning protrusions **56**A are provided. In the illustrated embodiment, like the second fixing screws **92**, two positioning protrusions **56**A are provided so as to be arranged in the direction of extension of the first fixing portion **52** with respect to the base plate portion **51**. Each of the illustrated positioning protrusions **56**A has a circular shape in plan view. The positioning protrusions **56**A may have any shape such as a polygonal shape and a semicircular shape, in plan view.

The main body **41** of the acoustic transducer **40** that is held in surface contact with the contact surface **54***a* of the positioning plate portion **54** is provided with positioning engaged portions corresponding to the positioning engaging portions. In the present embodiment, the positioning engaged portions are positioning holes **56**B. The positioning holes **56**B are recessed from a contacted surface **434***c* of the engaging plate portion **434** that is held in surface contact with the contact surface **54***a* of the positioning plate portion **54**, and the positioning protrusions **56**A of the positioning plate portions **54** are fitted into the positioning holes **56**B. In the present embodiment, the positioning holes **56**B are formed through the thickness of the engaging plate portion **434**.

The number of the positioning holes **56**B formed in the engaging plate portion **434** corresponds to the number of the positioning protrusions **56**A formed on the positioning plate portion **54**. In the illustrated embodiment, two positioning holes **56**B are formed so as to arranged in the width direction of the engaging plate portion **434**, like the shaft insertion hole **434**B.

Each positioning hole **56**B may have a shape in plan view that corresponds to a shape in plan view of each positioning protrusion **56**A, such as a circular shape. The positioning hole **56**B may be formed otherwise. In the present embodiment, a first positioning hole **56**B**1** has a circular shape in plan view corresponding to the positioning protrusion **56**A while a second positioning hole **56**B**2** is an elongated hole having a larger dimension in a direction of arrangement of the positioning holes **56**B**1**, **56**B**2** than each of the two positioning protrusions **56**A. In this structure, even when there is a difference between a spacing between the two positioning protrusions **56**A and a spacing between the two positioning holes **56**B, it is possible to insert the positioning protrusions **56**A into the corresponding positioning holes **56**B.

The locations of the positioning protrusions **56**A on the positioning plate portion **54** and the locations of the positioning holes **56**B in the engaging plate portion **434** are determined such that the positioning protrusions **56**A are inserted in the respective positioning holes **56**B in a state in which the shafts of the second fixing screws **92** screwed in the positioning plate portion **54** are inserted in the respective shaft insertion holes **434**B of the engaging plate portion **434**.

The surrounding plate portion **55** of the first fixing portion **52** has threaded plate portions **57** to which the first fixing screws **91** are screwed. Each threaded plate portion **57** extends inward of the surrounding plate portion **55** from its distal end in its extension direction, such that the threaded plate portion **57** is opposed to and parallel to the positioning plate portion **54**. The screw-fastening plate portions **436** of the fixing plate portion **433** of the main body **41** contact the respective threaded plate portions **57** in the direction toward the contact surface **54***a* from the negative (lower) side in the Z-axis direction in a state in which the engaging plate portion **434** of the main body **41** is in contact with the contact surface **54***a* of the positioning plate portion **54**.

The first fixing screws **91** are screwed in the threaded plate portions **57** in the direction toward the contact surface **54***a* from the negative (lower) side in the Z-axis direction. Like the second fixing screws **92**, the two first fixing screws **91** are disposed so as to be arranged in the extension direction of the first fixing portion **52** with respect to the base plate portion **51** (i.e., the right-left direction in FIG. **3**). A spacing distance between the two first fixing screws **91** is the same as a spacing distance between the two head insertion holes **436**A and between the two shaft insertion holes **436**B formed in the fixing plate portion **433**.

The locations of the first fixing screws **91** in the first fixing portion **52** are determined such that the shafts of the first fixing screws **91** are inserted in the respective shaft insertion holes **436**B of the fixing plate portion **433** in a state in which the shafts of the second fixing screws **92** are inserted in the respective shaft insertion holes **434**B of the engaging plate portion **434**.

In the structure described above, the fixing plate portion **433** can be fastened to the threaded plate portions **57** by means of the first fixing screw **91** by inserting the shafts of the first fixing screws **91** into the shaft insertion holes **436**B of the fixing plate portion **433**.

In the fixing plate portion **433**, the head insertion holes **436**A are formed so as to be continuous to the shaft insertion holes **436**B. In a state in which the heads of the first fixing screws **91**, which are screwed in advance in the respective threaded plate portions **57**, are inserted in the respective head insertion holes **436**A and the fixing plate portion **433** is thereby held in contact with the threaded plate portions **57**, namely, in a state in which the engaging plate portion **434** is held in contact with the contact surface **54***a*, the main body **41** is moved with respect to the support portion **50** in the direction along the contact surface **54***a*, whereby the shafts of the first fixing screws **91** can be inserted into the respective shaft insertion holes **436**B of the fixing plate portion **433**.

The shafts of the first fixing screws **91** are inserted into the respective shaft insertion holes **436**B of the fixing plate portion **433**, whereby the positioning protrusions **56**A of the positioning plate portion **54** are inserted into the respective positioning holes **56**B of the engaging plate portion **434**. That is, the positioning engaging portions of the support portion **50** come into engagement with the main body **41**.

The support portion **50** of the present embodiment further includes a guide surface **55***a* formed so as to extend in a direction orthogonal to the contact surface **54***a*. The guide surface **55***a* guides the main body **41** such that the head insertion holes **436**A overlap, in the axial direction, the respective first fixing screws **91** screwed in the support portion **50**.

In the present embodiment, the guide surface **55***a* of the support portion **50** is provided by a part of an inner surface of the surrounding plate portion **55** of the first fixing portion **52**. Specifically, the guide surface **55***a* is provided by an inner surface region of the surrounding plate portion **55** that is opposed to another inner surface region of the surrounding plate portion **55** corresponding to the portions at which the first fixing screws **91** are disposed, in a direction orthogonal to both of the axial direction (the Z-axis direction) of the first fixing screws **91** and the direction in which the two first fixing screws **91** are arranged.

In the present embodiment, the direction in which the head insertion hole **436**A and the shaft insertion hole **436**B of the main body **41** are arranged or are continuous to each other is orthogonal to the guide surface **55***a*. In particular, the head insertion holes **436**A of the main body **41** are more distant from the guide surface **55***a* than the shaft insertion holes **436**B. Consequently, when the main body **41** is moved with respect to the support portion **50** such that the shafts of the first fixing screws **91** are inserted into the respective shaft insertion holes **436**B of the fixing plate portion **433** after the heads of the first fixing screws **91** screwed in the support portion **50** have been inserted into the respective head insertion holes **436**A of the main body **41**, the main body **41** is moved away from the guide surface **55***a*.

The guide surface **55***a* has rails **58**A extending in the axial direction of the first fixing screws **91** (the second fixing screws **92**) screwed in the support portion **50**. A guided surface **435***a* of the main body **41** that is to contact the guide surface **55***a* has sliding portions **58**B configured to slide in the longitudinal direction of the rails **58**A. In the illustrated embodiment, each rail **58**A is in the form of a protrusion that protrudes from the guide surface **55***a* while each sliding portion **58**B is in the form of a recess that is recessed from the guided surface **435***a*. The rails **58**A and the sliding portions **58**B may be formed otherwise.

In the present embodiment, the positioning plate portion **54** of the first fixing portion **52** has a rectangular shape in plan view. The surrounding plate portion **55** is constituted by three flat plate portions **55**B, **55**C, **55**D extending respectively from three sides of the positioning plate portion **54** in the vertically downward direction (toward the negative side in the Z-axis direction). The threaded plate portions **57** are provided on one of the three flat plate portions **55**B, **55**C, **55**D, namely, a first flat plate portion **55**B that extends in a direction away from the base plate portion **51**. The two first fixing screws **91** screwed in the threaded plate portions **57** are disposed at respective positions in the first flat plate portion **55**B so as to be spaced apart from each other in the direction away from the base plate portion **51**.

The guide surface **55***a* of the support portion **50** is provided by an inner surface of one of the three flat plate portions **55**B, **55**C, **55**D, namely, a second flat plate portion **55**C which extends in the direction away from the base plate portion **51** and which is opposed to the first flat plate portion **55**B. The guided surface **435***a* of the main body **41** is provided by the connecting plate portion **435** of the frame portion **431**.

As shown in FIGS. **1** and **4**, the vibrating portion **49** of the acoustic transducer **40** is connected to the lower surface **16***b* of the soundboard **16**. The position at which the vibrating portion **49** is connected to the soundboard **16** is preferably determined to be a position at which the soundboard **16** is sandwiched by and between the vibrating portion **49** and the bridge **35** provided on the upper surface **16***a* of the soundboard **16**, for instance.

In the present embodiment, the retainer portion **476** of the distal joint portion **472** of the connecting unit **45** is connected to the lower surface **16***b* of the soundboard **16**, as shown in FIG. **4**. Further, the intervening member **60** is provided between the retainer portion **476** and the soundboard **16**, and the retainer portion **476** is fixed to the soundboard **16** via the intervening member **60**.

The intervening member **60** is undetachably fixed to the soundboard **16** by bonding or the like and is detachably fixed to the connecting unit **45** (the retainer portion **476**) by screwing or the like. The intervening member **60** is shaped like a plate and is disposed such that the thickness direction of the intervening member **60** coincides with the predetermined direction (the Z-axis direction).

A protruding portion and a recessed portion (both not shown) that are to be brought into engagement with each other are formed in one and the other of mutually facing surfaces of the intervening member **60** and the retainer portion **476**, whereby the retainer portion **476** of the connecting unit **45** is positioned with respect to the intervening member **60** in the direction orthogonal to the predetermined direction (the Z-axis direction).

As shown in FIGS. **3**-**5** and **7**, the installation structure for the acoustic transducer **40** according to the present embodiment has a cover member **70** that covers the acoustic transducer **40** fixed to the housing **11** via the support portion **50**, and so on.

The cover member **70** includes: a bottom plate portion **71** that covers the underside, in the vertical direction, of the acoustic transducer **40**; and a side plate portion **72** that extends from a peripheral edge of the bottom plate portion **71** in the vertically upward direction (toward the positive side in the Z-axis direction so as to cover the side portion of the acoustic transducer **40** (the main body **41**, in particular). The cover member **70** is shaped like a box opening in the vertically upward direction and in one side portion thereof. The opening of the cover member **70** at its one side portion is closed by the side surface of the back post **21** of the housing **11**. In the illustrated cover member **70**, the bottom plate portion **71** has a rectangular shape in plan view and the side plate portion **72** is constituted by three flat plate portions respectively extending from three sides of the bottom plate portion **71** in the vertically upward direction. The cover member **70** may be formed otherwise.

The cover member **70** is fixed to the support portion **50**. In the present embodiment, the cover member **70** is fixed to a second fixing portion **53** of the support portion **50**. Further, the cover member **70** is detachably fixed to the support portion **50** by screwing.

The second fixing portion **53** and the first fixing portion **52** are connected to the base plate portion **51** independently of each other. As shown in FIG. **7**, the first fixing portion **52** and the second fixing portion **53** are connected to the base plate portion **51** so as to form a space S therebetween in the Z-axis direction, in other words, with the space S interposed therebetween in the Z-axis direction, so that the first fixing portion **52** and the second fixing portion **53** are connected to the base plate portion **51** independently of each other. The second fixing portion **53** extends from a second position that is distant, by a suitable distance in the vertically downward direction, from a first position at which the first fixing portion **52** is fixed to the base plate portion **51**. Specifically, the second fixing portion **53** extends from the second position of the base plate portion **51** in the direction away from the side surface of the back post **21**. (The direction is one example of the second direction intersecting the first direction.) In other words, the first fixing portion **52** extends from the first position of the base plate portion **51**, and the second fixing portion **53** extends from the second position of the base plate portion **51** different from the first position. The second position of the base plate portion **51** is different from the first position in the predetermined direction (the Z-axis direction). The space S is accordingly formed between a lower end of the first fixing portion **52** and an upper end of the second fixing portion **53**, and the first fixing portion **52** and the second fixing portion **53** extend in the direction away from the side surface of the back post **21**.

In the present embodiment, the second fixing portion **53** is constituted by a pair of plate-like extending portions **59** formed integrally with lateral portions of the base plate portion **51**.

Each plate-like extending portion **59** is a strip-like plate extending from the lateral (side) portions of the base plate portion **51** in the direction away from the back post **21**. There are formed, at distal ends of the respective plate-like extending portions **59** in the extension direction thereof, fixing plate portions **59**A through which the cover member **70** is fixed to the support portion **50**. The fixing plate portions **59**A are disposed in parallel with the positioning plate portions **54** of the first fixing portion **52**. To each of the fixing plate portions **59**A, a third fixing screw **93** for fastening the cover member **70** is screwed from one side of the positioning plate portion **54** on which the contact surface **54***a* is located.

In the present embodiment, the bottom plate portion **71** of the cover member **70** is fastened to the second fixing portion **53** by the third fixing screws **93**. To this end, screw insertion holes **73** are formed through the thickness of the bottom plate portion **71** of the cover member **70** for permitting the third fixing screws **93** to pass therethrough.

In the present embodiment, elastically deformable first cushion members **81** are provided between the cover member **70** and the second fixing portion **53**. Further, the cover member **70** is pressed onto the housing **11** via elastically deformable second cushion members **82**. These cushion members **81**, **82** are formed of urethane foam, for instance.

In the present embodiment, one first cushion member **81** is provided between the bottom plate portion **71** of the cover member **70** and one fixing plate portion **59**A of the second fixing portion **53**, and another first cushion member **81** is provided between the bottom plate portion **71** and another fixing plate portion **59**A. The second cushion members **82** are disposed between the opening at the one side portion of the cover member **70** and the back post **21** of the housing **11**. In the present embodiment, the screw insertion holes **73** of the cover member **70** are designed such that the second cushion members **82** are sandwiched between the cover member **70** and the housing **11**.

Specifically, each screw insertion hole **73** is constituted by a head insertion hole **73**A and a shaft insertion hole **73**B that are continuous to each other. The head insertion hole **73**A has an inner diameter larger than a diameter of the head of the third fixing screw **93**, and the shaft insertion hole **73**B has an inner diameter smaller than the diameter of the head of the third fixing screw **93** and larger than a diameter of the shaft of the third fixing screw **93**. Each head insertion hole **73**A is located nearer to the opening at the one side portion of the cover member **70** than the shaft insertion hole **73**B.

In the structure described above, when the cover member **70** is moved toward the housing **11** (the back post **21**) such that the shafts of the third fixing screws **93** are inserted into the respective shaft insertion holes **73**B of the screw insertion holes **73** after the heads of the third fixing screws **93** screwed in the second fixing portion **53** have been inserted into the respective head insertion holes **73**A of the screw insertion holes **73**, the cover member **70** is pressed onto the housing **11** via the second cushion members **82**.

There will be next explained one example of a method of installing the acoustic transducer **40** of the present embodiment on the piano **1**.

In the method of the present embodiment, the main body **41** and the support portion **50** constructed as described above are prepared in advance. Initially, a step of fixing the support portion for fixing the support portion **50** to the housing **11** is performed. In this step, the base plate portion **51** is superposed on the side surface of the back post **21** and is fixed to the back post **21** by screwing or the like.

In a state after the step of fixing the support portion has been performed, the contact surface **54***a* of the support portion **50** (the positioning plate portion **54**) faces vertically downward (toward the negative side in the Z-axis direction). Further, the first fixing portion **52** of the support portion **50** including the contact surface **54***a* is located at a higher position than the second fixing portion **53** in the vertical direction.

A step of fixing the intervening member for fixing the intervening member **60** to the soundboard **16** is performed before or after the step of fixing the support portion. In this step, the intervening member **60** is fixed to the lower surface **16***b* of the soundboard **16** preferably by one of or both of bonding and screwing, for instance.

In one of the step of fixing the support portion and the step of fixing the intervening member that is later performed, the support portion **50** and the intervening member **60** are preferably positioned relative to each other using a jig not shown. In particular, the support portion **50** and the intervening member **60** are preferably positioned relative to each other in the direction orthogonal to the predetermined direction (the Z-axis direction), namely, in the X-axis direction and the Y-axis direction in FIGS. **1** and **2**.

Subsequently, a step of fixing the acoustic transducer for fixing the acoustic transducer **40** with respect to the intervening member **60** and the support portion **50** is performed.

In the present embodiment, the vibrating portion **49** includes the vibrating unit **44** and the connecting unit **45** that are mutually separable. Thus, in the step of fixing the acoustic transducer, there is first performed a step of fixing the connecting unit for fixing the connecting unit **45** of the vibrating portion **49** to the intervening member **60**. In this step, the retainer portion **476** of the distal joint portion **472** is initially disposed so as to be positioned relative to the intervening member **60**. As described above, the protruding portion and the recessed portion (both not shown) configured to engage with each other are formed in one and the other of the mutually facing surfaces of the intervening member **60** and the retainer portion **476**. It is thus possible to position the retainer portion **476** relative to the intervening member **60**. The retainer portion **476** is then fastened to the intervening member **60** by screwing. In a state after this step has been performed, the vibrating-side shaft portion **461** of the connecting unit **45** passes through the opening hole **54**B of the positioning plate portion **54** of the support portion **50**.

In the step of fixing the acoustic transducer, there is performed a step of fixing the main body for fixing the main body **41** of the acoustic transducer **40** to the support portion **50** after the step of fixing the connecting unit. In a period from before the step of fixing the support portion to before the step of fixing the main body, the first fixing screws **91** and the second fixing screws **92** are screwed in the respective corresponding portions of the support portion **50**. In the step of fixing the main body, the following first through third mounting steps are performed in order.

In the first mounting step, the main body **41** is brought into contact with the contact surface **54***a* of the support portion **50** such that the support portion **50** is disposed between the main body **41** and the soundboard **16**. Further, as shown in FIG. **8**, the heads of the first fixing screws **91** are inserted into the respective head insertion holes **436**A formed in the fixing plate portion **433** (the screw-fastening plate portions **436**) of the main body **41**.

In the first mounting step, the main body **41** is moved toward the contact surface **54***a* of the support portion **50** toward the positive side in the Z-axis direction in a state in which the main body **41** is held in contact with the guide surface **55***a* of the support portion **50**. By permitting the main body **41** to be held in contact with the guide surface **55***a* of the support portion **50**, the head insertion holes **436**A of the main body **41** can be positioned so as to overlap the respective first fixing screws **91** in the axial direction thereof, i.e., the Z-axis direction.

In the present embodiment, the rails **58**A extending in the axial direction of the first fixing screws **91** are formed on the guide surface **55***a* of the support portion **50**, and the sliding portions **58**B configured to slide in the longitudinal direction of the rails **58**A are formed on the guided surface **435***a* of the main body **41** that contacts the guide surface **55***a*. It is thus possible, in the first mounting step, to move the main body **41** in the axial direction of the first fixing screws **91**, i.e., the Z-axis direction, by the rails **58**A and the sliding portions **58**B.

In the first mounting step, the vibrating-side shaft portion **461** of the connecting unit **45** passes through the hole **434**A (FIGS. **4** and **5**) of the frame portion **431** (the engaging plate portion **434**) of the main body **41**, the insertion hole **420** of the magnetic-path forming portion **42**, and a hole of the vibrating unit **44** attached to the magnetic-path forming portion **42** (FIG. **6**).

In a state after the first mounting step has been performed, the engaging plate portion **434** of the main body **41** is in contact with the contact surface **54***a* of the support portion **50**, but the shafts of the second fixing screws **92** are not yet inserted in the shaft insertion holes **434**B formed in the engaging plate portion **434**, as shown in FIG. **8**. Further, the positioning protrusions **56**A (the positioning engaging portions) formed on the contact surface **54***a* of the support portion **50** do not yet engage with the positioning holes **56**B (the positioning engaged portions) formed in the engaging plate portion **434**.

In the second mounting step, the main body **41** is moved with respect to the support portion **50** in the direction along the contact surface **54***a* (upward in FIG. **8**) with the main body **41** held in contact with the contact surface **54***a* of the support portion **50**, whereby the shafts of the first fixing screws **91** are inserted into the respective shaft insertion holes **436**B from the respective head insertion holes **436**A of the fixing plate portion **433**, as shown in FIG. **3**. At the same time, the positioning protrusions **56**A of the support portion **50** are brought into engagement with or inserted into the respective positioning holes **56**B of the main body **41**, whereby the main body **41** is restricted from moving in the direction along the contact surface **54***a* with respect to the support portion **50**.

In the second mounting step, the main body **41** is moved with respect to the support portion **50**, whereby the shafts of the second fixing screws **92** are inserted into the respective shaft insertion holes **434**B of the engaging plate portion **434**.

In a state after the second mounting step has been performed, the fixing plate portion **433** (the screw-fastening plate portions **436**) of the main body **41** is interposed between the heads of the first fixing screws **91** and the support portion **50** (the threaded plate portions **57**), so that the fixing plate portion **433** of the main body **41** is supported by the heads of the first fixing screws **91**. Further, the engaging plate portion **434** of the main body **41** is interposed between the heads of the second fixing screws **92** and the support portion **50** (the positioning plate portion **54**), so that the engaging plate portion **434** of the main body **41** is supported by the heads of the second fixing screws **92**. That is, the main body **41** is prevented from moving away from the support portion **50**.

In particular, the contact surface **54***a* of the support portion **50** faces vertically downward (toward the negative side in the Z-axis direction), and the main body **41** is attached to the support portion **50** from the lower side of the support portion **50** in the vertical direction, so that the main body **41** is prevented from dropping in the state after the second mounting step has been performed.

In the state after the second mounting step has been performed, the positioning protrusions **56**A of the support portion **50** are held in engagement with or fitted in the respective positioning holes **56**B of the main body **41**, so that the main body **41** can be easily positioned relative to the support portion **50**.

In the third mounting step, the main body **41** is fastened to the support portion **50** by the first fixing screw **91** such that the fixing plate portion **433** (the screw-fastening plate portions **436**) of the main body **41** is sandwiched between the support portion **50** (the threaded plate portions **57**) and the heads of the first fixing screw **91**. Further, in the third mounting step, the main body **41** is fastened to the support portion **50** by the second fixing screws **92** such that the engaging plate portion **434** of the main body **41** is sandwiched between the support portion **50** (the positioning plate portion **54**) and the heads of the second fixing screws **92**.

The main body **41** is fixed to the first fixing portion **52** of the support portion **50** by performing the first through third mounting steps.

In a period from after the second mounting step to after the third mounting step of the step of fixing the main body, the vibrating unit **44** of the vibrating portion **49** is fixed to the connecting unit **45**. In this instance, the vibrating-side shaft portion **461** of the connecting unit **45** that has been inserted into the hole of the vibrating unit **44** in the first mounting step is preferably fixed to the vibrating unit **44** by the fixing means **440**.

In the present embodiment, there is performed a step of attaching the cover member for attaching the cover member **70** to the second fixing portion **53** of the support portion **50** after all of the steps described above have been performed. Further, in a period from before the step of fixing the support portion to before the step of attaching the cover member, the third fixing screws **93** are screwed in the second fixing portion **53** of the support portion **50**.

In the step of attaching the cover member, the cover member **70** is initially moved toward the support portion **50** from the lower side in the vertical direction, and the heads of the third fixing screws **93** are inserted into the respective head insertion holes **73**A of the screw insertion holes **73** formed in the bottom plate portion of the cover member **70**. The cover member **70** is subsequently moved toward the housing **11** (the back post **21**), namely, toward the right side in FIG. **3**, whereby the shafts of the third fixing screws **93** are inserted from the respective head insertion holes **73**A of the screw insertion holes **73** into the respective shaft insertion holes **73**B. Thus, the cover member **70** can be pressed onto the housing **11** with the second cushion members **82** interposed therebetween.

In this way, the acoustic transducer **40** is installed.

In the method explained above, the support portion **50** is positioned relative to the housing **11** and the intervening member **60** fixed to the soundboard **16**, and is fixed to the housing **11**. Further, the main body **41** of the acoustic transducer **40** is positioned relative to the support portion **50** by the contact surface **54***a* of the support portion **50** and the positioning protrusions **56**A and the positioning holes **56**B, and is fixed to the support portion **50**. Consequently, the axis C**1** of the magnetic-path forming portion **42**, the axis C**2** of the vibrating unit **44**, the axis of the vibrating-side shaft portion

461 of the connecting unit **45**, and the axis C**3** of the vibrated-side shaft portion **462** can coincide with one another.

When a drive signal based on an audio signal is input to the voice coil **442** of the acoustic transducer **40** in the piano **1** on which the acoustic transducer **40** is installed, the vibrating unit **44** vibrates in the predetermined direction (the Z-axis direction). The vibration of the vibrating unit **44** is transmitted to the soundboard **16** by the connecting unit **45**, so that the soundboard **16** vibrates in the predetermined direction. The vibration of the soundboard **16** propagates through the air, so that sounds are generated.

In an instance where the piano **1** on which the acoustic transducer **40** is installed undergoes displacement of the soundboard **16** in the orthogonal direction that is orthogonal to the predetermined direction due to deterioration over years, the intervening member **60** and the retainer portion **476** of the distal joint portion **472** that are fixed to the soundboard **16** are also displaced in the orthogonal direction with respect to the magnetic-path forming portion **42**.

In the present embodiment, the connecting unit **45** includes the intermediate joint portion **471** and the distal joint portion **472**. When the intervening member **60** and the retainer portion **476** of the distal joint portion **472** are displaced in the orthogonal direction, the axis C**3** of the vibrated-side shaft portion **462** is inclined by the intermediate joint portion **471** and the distal joint portion **472** with respect to both of the predetermined direction and the axis C**2** of the magnetic-path forming portion **42**. It is consequently possible to prevent the axes of the vibrating unit **44** and the vibrating-side shaft portion **461** from being inclined with respect to the predetermined direction. In other words, it is possible to prevent the axis C**2** of the vibrating unit **44** fixed to the vibrating-side shaft portion **461** from being inclined with respect to the axis C**1** of the magnetic-path forming portion **42** that is parallel to the predetermined direction.

According to the installation structure for the acoustic transducer **40**, the piano **1** including the same, and the method for installing the acoustic transducer **40**, the shafts of the first fixing screws **91** screwed in advance in the support portion **50** are inserted into the shaft insertion holes **436**B formed in the fixing plate portion **433** (the screw-fastening plate portions **436**) of the main body **41**, and the shafts of the second fixing screws **92** screwed in the support portion **50** in advance are inserted into the shaft insertion holes **434**B formed in the engaging plate portion **434**. Consequently, in a state before the main body **41** is fastened to the support portion **50** by the first and second fixing screws **91**, **92**, the fixing plate portion **433** (the screw-fastening plate portions **436**) and the engaging plate portion **434** of the main body **41** are respectively supported by the first and second fixing screws **91**, **92**, whereby the main body **41** is prevented from moving away from the support portion **50**. As a result, work for installing and replacing the acoustic transducers **40** can be facilitated.

In a state in which the shafts of the first and second fixing screws **91**, **92** are fitted in the shaft insertion holes **436**B, **434**B, the positioning protrusions **56**A of the support portion **50** are held in engagement with the positioning holes **56**B of the main body **41**, so that the main body **41** can be easily positioned with respect to the support portion **50**. That is, the acoustic transducer **40** can be easily positioned with respect to the soundboard **16** at the same time when the acoustic transducer **40** is installed.

According to the present embodiment, when the heads of the first fixing screws **91** screwed in the support portion **50** are inserted into the head insertion holes **436**A formed in the fixing plate portion **433** of the main body **41**, the main body **41** is brought into contact with the guide surface **55***a* of the support portion **50**, whereby the head insertion holes **436**A of the main body **41** are positioned so as to overlap the respective first fixing screws **91** in the axial direction thereof (the Z-axis direction). Consequently, the heads of the first fixing screws **91** can be easily inserted into the respective head insertion holes **436**A of the main body **41**. That is, work for mounting the main body **41** on the support portion **50** can be facilitated.

According to the present embodiment, the rails **58**A extending in the axial direction of the first fixing screws **91** are formed on the guide surface **55***a* of the support portion **50**, and the sliding portions **58**B to slide in the longitudinal direction of the rails **58**A are formed on the guided surface **435***a* of the main body **41**. It is consequently possible to prevent, with high reliability, the axis of each head insertion hole **436**A formed in the fixing plate portion **433** of the main body **41** and the axis of each first fixing screws **91** from deviating relative to each other. It is thus possible to easily insert the heads of the first fixing screws **91** into the respective head insertion holes **436**A of the main body **41**.

According to the installation structure for the acoustic transducer **40** and the piano **1** including the same, the base plate portion **51** of the support portion **50** is held in surface contact with the housing **11** so as to be fixed thereto. It is thus possible to prevent the base plate portion **51** from being vibrated even if the first fixing portion **52** of the support portion **50** is vibrated due to vibration of the vibrating portion **49** of the acoustic transducer **40**. Further, the second fixing portion **53** of the support portion **50** is connected to the base plate portion **51** independently of the first fixing portion **52**, whereby vibration of the first fixing portion **52** is prevented from being transmitted to the second fixing portion **53**. In other words, the cover member **70** fixed to the second fixing portion **53** is prevented from being vibrated due to vibration of the vibrating portion **49**. Consequently, sounds generated from the soundboard **16** that is vibrated by the acoustic transducer **40** can be suitably obtained.

According to the present embodiment, the first cushion members **81** that are elastically deformable are interposed between the cover member **70** and the second fixing portion **53**. Even if the second fixing portion **53** is vibrated due to vibration of the vibrating portion **49**, the first cushion members **81** are elastically deformed, whereby it is possible to prevent vibration of the second fixing portion **53** from being transmitted to the cover member **70**.

According to the present embodiment, the cover member **70** is pressed onto the housing **11** via the second cushion members **82** that are elastically deformable. Even if vibration of the vibrating portion **49** is transmitted to the cover member **70**, the second cushion members **82** are elastically deformed, whereby it is possible to prevent the cover member **70** from being vibrated.

While the embodiment of the present invention has been explained, it is to be understood that the invention is not limited to the details of the illustrated embodiment, but may be embodied with various other changes without departing from the scope of the invention defined in the attached claims.

For instance, each positioning engaging portion of the support portion **50** configured to position the main body **41** relative to the support portion **50** may be a positioning recess that is recessed from the contact surface **54***a* of the positioning plate portion **54**. In this case, the engaging plate portion **434** of the main body **41** is preferably provided with a positioning protrusion, as the positioning engaged portion, which is formed so as to protrude from the contacted surface **434***c* of the engaging plate portion **434** and configured to be inserted into the positioning recess.

The joint portion **47** of the connecting unit **45** may be constituted by only one of the intermediate joint portion **471** and the distal joint portion **472**. In an instance where the joint portion **47** is constituted only by the distal joint portion **472**, the shaft portion **46** of the connecting unit **45** is preferably formed so as to extend from the vibrating unit **44** to the soundboard **16**, as in the illustrated embodiment. In this instance, the distal joint portion **472** allows the entirety of the shaft portion **46** to incline with respect to the predetermined direction (the Z-axis direction).

The joint portion **47** of the connecting unit **45** may have any structure other than the ball-joint structure in the illustrated embodiment. For instance, the joint portion **47** may have a universal joint structure.

The connecting unit **45** may be constituted only by the shaft portion **46** without the joint portion **47**.

In the illustrated embodiment, the magnetic-path forming portion **42** is fixed to the fixing plate portion **433** such that the vibrating unit **44** is located near to the fixing plate portion **433** of the restricting holder portion **43**. The magnetic-path forming portion **42** may be fixed otherwise. For instance, the magnetic-path forming portion **42** may be fixed to the fixing plate portion **433** such that the vibrating unit **44** is located near to the engaging plate portion **434** of the restricting holder portion **43**. In this case, the vibrating portion **49** may be configured not to have the connecting unit **45** and to have only the vibrating unit **44**, and the vibrating unit **44** may be detachably connected to the intervening member **60**.

The present installation structure for the acoustic transducer **40** may be configured not to have the intervening member **60**, for instance. In this case, it is preferable to connect the vibrating portion **49** directly to the soundboard **16**.

When the acoustic transducer **40** is installed in an instance in which the connecting unit **45** is undetachably fixed to the vibrating unit **44** or in an instance in which the vibrating portion **49** does not include the connecting unit **45**, it is preferable to fix the vibrating portion **49** to the soundboard **16** after the step of fixing the support portion and the step of fixing the main body in the illustrated embodiment have been performed.

The support portion **50** for supporting the acoustic transducer **40** may be fixed to the outer rim **19** or the inner rim **20**, other than the back post **21** of the housing **11**.

The soundboard **16** is illustrated as one example of the vibrated body which is to be vibrated and on which the acoustic transducer **40** is installed. The vibrated body may be other members of the housing **11** that may undergo displacement due to deterioration over years, for instance.

The acoustic transducer **40** can be installed in a structure in which the vibrated body does not undergo displacement and the member of the housing **11** to which the magnetic-path forming portion **42** is fixed may undergo displacement due to deterioration over years.

The acoustic transducer **40** is applicable to musical instruments having the vibrated body such as the soundboard **16**. For instance, the acoustic transducer **40** is applicable to various musical instruments such as other keyboard musical instruments such as upright pianos, stringed musical instruments such as acoustic guitars and violins, percussion instruments such as drums and timpani, and electronic musical instruments such as electronic pianos.

What is claimed is:

1. An installation structure for an acoustic transducer configured to vibrate a vibrated body of a musical instrument in a first direction so as to permit the vibrated body to generate sounds, comprising:

the acoustic transducer having a main body and a vibrating portion configured to vibrate in the first direction with respect to the main body;

a support portion to be fixed to a housing of the musical instrument so as to support the main body of the acoustic transducer; and

a cover member fixed to the support portion so as to cover the acoustic transducer,

wherein the support portion includes a base plate portion to be held in surface contact with the housing so as to be fixed thereto, a first fixing portion to which the main body of the acoustic transducer is fixed and which is configured to support the main body, and a second fixing portion to which the cover member is fixed, and

wherein the first fixing portion and the second fixing portion are connected to the base plate portion independently of each other.

2. The installation structure for the acoustic transducer according to claim **1**, wherein an elastically deformable cushion member is interposed between the cover member and the second fixing portion.

3. The installation structure for the acoustic transducer according to claim **1**, wherein the cover member is configured to be pressed onto the housing.

4. The installation structure for the acoustic transducer according to claim **1**, wherein the first fixing portion and the second fixing portion extend from the base plate portion in a second direction intersecting the first direction so as to form a space therebetween.

5. The installation structure for the acoustic transducer according to claim **4**, wherein the first fixing portion extends, in the second direction, from a first position of the base plate portion, and wherein the second fixing portion extends, in the second direction, from a second position of the base plate portion different from the first position.

6. The installation structure for the acoustic transducer according to claim **5**, wherein the first position and the second position of the base plate portion are different from each other.

7. The installation structure for the acoustic transducer according to claim **5**, wherein the second direction is a direction away from a surface of the base plate portion that is to be held in contact with the housing.

8. The installation structure for the acoustic transducer according to claim **1**, wherein the acoustic transducer is configured to be installed on an exterior portion of the musical instrument.

9. A musical instrument, comprising:

a vibrated body;

an acoustic transducer configured to vibrate the vibrated body in a first direction so as to permit the vibrated body to generate sounds, the acoustic transducer having a main body and a vibrating portion configured to vibrate in the first direction with respect to the main body;

an installation structure for the acoustic transducer; and

a housing; and

wherein the installation structure includes a support portion fixed to the housing so as to support the main body of the acoustic transducer, and a cover member fixed to the support portion so as to cover the acoustic transducer;

wherein the support portion includes a base plate portion to be held in surface contact with the housing so as to be fixed thereto, a first fixing portion to which the main body of the acoustic transducer is fixed and which is configured to support the main body, and a second fixing portion to which the cover member is fixed; and wherein the first fixing portion and the second fixing portion are connected to the base plate portion independently of each other.

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